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(54) A method of making a seamless screen cylinder.

(57) Screen cylinders for removing contaminant particles from papermaking stock are formed with a seamless cylinder body (12). The body (12) is formed by centrifugal casting or by cold roller extrusion. A plurality of closely spaced screening holes or slots (25) are formed in the wall (20) of the cylindrical section (12) by laser cutting, by directing a focused laser beam at an outer surface (32) of the wall (20) while focusing the beam at a location intermediate the outer surface (32) and the inner surface (30), to form a slot (25) which has tapered walls (40). The walls (40) are formed or defined by smooth glassy recast surfaces and are harder than the body. Wear bars (35) may be applied to the inside surface (30) in the form of a bead or beads of weld material.

FIG-4

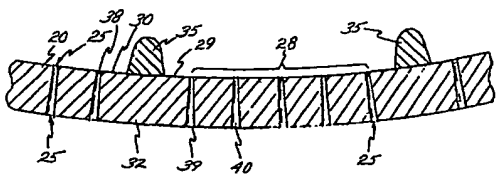
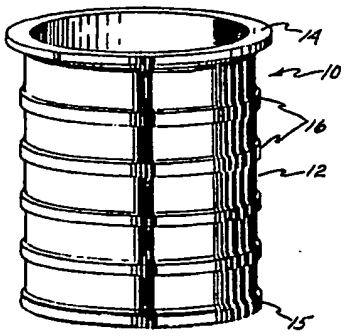


FIG-1



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A METHOD OF MAKING A SEAMLESS SCREEN CYLINDER

Screen cylinders according to the prior art are formed by machining the required slots or grooves in a flat plate of metal material, such as stainless steel, and then rolling the material into the shape of a cylinder, and welding the rolled plate at the abutting ends to form a welded seam. Thereafter end rings, formed from bar stock, are rolled, welded at their respective ends, and attached by welding to the cylinder plate, at its respective ends. One or more intermediate reinforcing rings, also formed from rolled bar stock, are attached by welding at longitudinally spaced locations on the outer surface of the rolled screen plate. An example of such a fabricated cylinder screen is shown in Hatton et al, U. S. 4,017,387, issued April 12, 1977. Such cylinders are subject to fatigue failures.

The rolling of the plates and bars causes compression on an inside diameter and tension at an outside diameter. Also, the screening openings become inherently distorted by the rolling process. Since a large number of slots terminate at common positions on the plate to form rows of slots, rolling is inherently nonuniform circumferentially of the plate due to the differences in strengths between a slotted and a non-slotted region, and stress concentration points are formed at the terminal ends of the slots.

The welding along the plate seam and along the end rings and the intermediate rings inherently creates lines of weakness where a weld may not be as strong as the original material. Also a weld has a lower tolerance to fatigue and catastrophic failure of screen cylinders is commonly associated with a weld or a slot.

This invention includes a centrifugally cast body, which is initially cast approximately to the desired finished shape. Centrifugal casting techniques provide a product having superior uniformity of grain structure and superior dimensional tolerance as to roundness, in cylindrical metal parts. Where end rings and/or intermediate reinforcing rings or ribs are required, they are cast in place during the centrifugal casting. After casting, the cast part may be machined to a high degree of accuracy about a true center, and thereby provides a seamless body which is inherently free of internal stresses, and has a uniform and coherent grain structure.

An alternative method of making the seamless basic body or cylinder is by cold working a seamless blank using a roller extrusion process. If end rings and/or intermediate reinforcing rings or ribs are desired, they may be formed during the cold working. The starting workpiece may be a centrifugal casting. The piece is cold worked by the roller extrusion process, as practiced as a proprietary process by Kaiser Rollmet Division of Kaiser Aerospace & Electronics Company, 1822 Deer Avenue, Irvine, California. Such a cold worked screen is seamless and is characterized by a higher strength as compared to an "as cast" material.

The "Rollmet" process provides a precision seamless cylindrical shape which is uniquely suited for the production of thin walled and complex cylindrical shapes in diameters from 4 inches up to 72 inches.

The process results in a fine grain structure which results from the combination of cold working of the metal plus re-crystallization and work hardening. The work piece can therefore be a blank cylinder of required specifications with respect to wall thickness and length, taking into the account the radial and axial expansion inherent in the radial forging process to arrive at a desired wall thickness and axial length in the finished product, as is known in this art.

Two methods of radial forging are available. One involves an internal roll extrusion in which the blank or work piece is placed inside a rotating one piece cylindrical die ring, and rollers inside the blank are displaced radially outwardly while the tube outside diameter remains confined and constant, thereby providing a high accuracy thin wall. This is a preferred process. An alternative process is available by which outside rollers operate in conjunction with a mandrel so that as the blank is rotated and pulled through the rollers, the I.D. remains constant while the wall thickness and the O.D. is reduced. In either technique, a truly cylindrical wall is formed to accurate dimensions and is simultaneously cold worked to increase the strength over its "as cast" condition.

The openings or slots, as the case may be, are formed by a laser cutting technique, by focusing a laser cutting beam or by directing such laser beam energy, at the outlet surface toward the inlet surface as shown in U. S. Patent No. 4,795,560. To make a slot, the cylinder and/or the beam may be moved in relation to the other. The high degree of accuracy of the roundness or trueness of the centrifugal cast product permits the laser cutting head to be positioned in close relation to the outer surface to be cut while one or the other is moved. The need to program for an out-of-round condition is reduced or eliminated.

The laser cutting of openings, such as slots, does not inherently create any additional stress concentration points in the cylinder. Since the body is substantially free of stresses, and free of welded connections, the perceived failure modes are re-

duced, with the expectation of longer life or fewer catastrophic failures. Such a cylinder will inherently absorb a larger number of flex cycles before exhibiting induced fatigue failures. If desired, turbulence inducing bars, also known as "wear" bars, may be applied along the inside surface of the cylinder, either before or after laser cutting, such as by welding a bead as shown in U. S. Patent No. 4,795,560. The welding of a surface bead does not create an inherent weakness since the weld does not excessively penetrate the thickness of the wall material, and since the wear bars do not carry a load.

The roller extrusion cold work process or the centrifugal casting process permits the manufacture of screen cylinder bodies of more than one material. The main portion of such a body may be formed of basic stainless steel, and an inside wear surface of a harder or more wear resistant material may be used. In casting, the harder inside material is added after the body is cast of the basic material.

The invention may be described as a method of manufacturing a screen cylinder for removing contaminant particles from papermaking stock in which a cylinder body is formed with an intermediate cylindrical section and in which a plurality of closely spaced screening holes or slots are formed in the cylindrical section, characterized by the steps of forming the cylinder body as an integral seamless unit free or devoid of internal stresses, and at the same time forming the intermediate section of the body with a generally uniform radial thickness throughout the intermediate section to define an inner surface and an outer surface, and forming the holes or slots by directing a focused laser beam at the outer surface of the cylindrical section, thereby forming a hole or slot with tapered walls.

The invention may be further characterized by the steps of forming the cylindrical body with a pair of end rings which are integral with the body and at least one intermediate reinforcing rib also integral with the body and positioned on the outer surface of the intermediate section between the end rings, and in which the holes or slots are formed in spaces between the rib and the end rings.

The method may also be further characterized by the step of moving the cylinder body with respect to the laser beam to form or cut slots through the intermediate section. The body may be formed by the steps of centrifugally casting or by the steps of cold roller extrusion.

The method according to this invention may be further characterized by the steps of focusing the laser beam at or against the outer surface of the body and positioning the focus at a point or region which is intermediate or between the outer and inner surfaces of the intermediate section, adjacent or close to the inner surface, to form a hole or a slot which has tapered walls, and in which the walls are wider apart at the outer surface than they are at the inner surface.

The invention may be further characterized by the steps of applying wear bars, by applying beads of weld material, by welding the beads to the inner surface of the cylindrical body so that the wear bars do not intersect the holes or slots formed therethrough.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in which:

Fig. 1 is a perspective view of a body of a screen cylinder which has been made either by centrifugal casting or by cold roller extrusion.

Fig. 2 is an enlarged fragmentary detail of a portion of the screen side wall after the slots have been cut and wear bars applied, looking at an inside surface;

Fig. 3 is a view of a finished cylinder screen according to this invention, partially in section;

Fig. 4 is a fragmentary section through the side wall;

Fig. 5 is an enlarged sectional view through one of the slots;

Fig. 6 is a somewhat diagrammatic view of a screen cylinder according to this invention showing a chevron slot arrangement;

Fig. 7 is an enlarged inside elevational view showing another slot arrangement;

Fig. 8 is a view similar to Fig. 7 showing a still different arrangement of slots; and

Fig. 9 is an enlarged fragmentary section of the wall of the cylinder showing the formation of inclined holes or slots slopping with the direction of movement of the stock.

Referring to the drawings, and particularly to Fig. 1, a body 10 of a screening cylinder body 10 is shown as made according to this invention. The body 10 may be a finished centrifugal casting, which is cast initially to the desired size and which may have a finished or machined inner and/or outer surface as required. Such an "as cast" blank is inherently free of internal stresses and is characterized by a uniform grain pattern throughout. The blank is entirely seamless, and free or devoid of any welds which could form high stress points or points of weakness. The techniques for centrifugally casting of cylindrical bodies are well known in the art, and reference may be had to U. S. Patents Nos. 2,843,755, 4,124,056, 3,293,708, and 743,077. Either vertical or horizontal centrifugal casting techniques may be used as well known in the industry.

Alternatively, the body 10 may be cold worked. Preferably, a centrifugal cast blank is employed, in the shape of a simple cylinder, with a controlled

inside or outside diameter, and is radially cold worked by inside roller pressure against an outside mandrel or outside roller pressure against an inside mandrel, as known as the "Roll Extrusion" process practiced by Kaiser Rollmet Division, Kaiser Aerospace & Electronics Company, 1822 Deer Avenue, Irvine, California. In either process, a central or intermediate cylindrical screening portion 12 of defined thickness is formed with accurately spaced inner and outer surfaces.

A first integral end ring 14 is formed on one end and a second integral end ring 15 formed on the opposite axial end thereof, as may be required for utilization in the particular screening apparatus. The body 10, during forming, may also be provided with one or more intermediate enforcing rings 16.

Where the entire body 10 is centrifugally cast to the finished size, after casting it may be surface finished, at least on the inside surface, by a machine tool to remove any residual slag and/or irregularities, and to provide a cylindrically true surface along the inside surface. The end rings 14 and 15, and the intermediate rings 16, are not separate or discrete elements, such as shown in patent 4,017,387, but are unitary and integral parts of the body 10 itself, and thus are integral with the intermediate cylindrical portion 12 and the generally cylindrical side wall 20 defined by this section.

The side wall 20, as shown in Figs. 2 and 4, is formed with a generally uniform thickness throughout, in the axial regions between the reinforcing rings, such as between an intermediate ring 16 and an adjacent end ring 14 or 15. The configurations of the end rings 14 and 15 permit the completed screen cylinder to be received within suitable high turbulence paper stock screening apparatus, of the general type as shown in Seifert, U. S. Patent No. 3,849,302 issued November 19, 1974 and the patent of Chupka and Seifert, U. S. Patent No. 4,155,841. Different models of such high pressure screening apparatus will require different overall screen cylinder configurations, within the scope of this invention, and as such may or may not have end or intermediate rings, or may have rings of a particular shape.

The body 10 is free of any connecting seams and is devoid of any rolled or bent parts which would contain or which would induce residual stresses within the body. In fact, the body 10 is substantially free of internal stresses, is of a uniform grain structure throughout, and exhibits a high strength.

Openings, such as in the form of holes and/or slots, are formed in the side wall 20 by laser cutting. The openings, illustrated by the slots 25, are formed in the intermediate wall portions 26 (Fig. 3) defined between the rings 16. Fig. 1 illustrates the body 10 before the cutting of the openings 25 and represents a form of the invention which may be pre-manufactured and stored for subsequent cutting to a customer's specification. Since a customer's specifications may vary, the laser cutting technique of this invention, in combination with the wear bar application technique of this invention, provides a high degree of versatility in the meeting of specific customer requirements.

The cylinder body 10, as shown in Fig. 3, is formed with circumferential rows of generally axially oriented slots 25, the rows being positioned in the wall portions 26 between the reinforcing rings 16. The slots 25 in each of the annular bands or rows are formed into individual slot groups 28 defining axially extending land areas 29 therebetween, as shown in Fig. 4. The individual slots 25, as shown, extend through the wall 20 of the body portion, through an inner or inlet surface 30 to an outside or outlet surface 32, as shown in Fig. 4, in generally normal relation to these surfaces.

The intermediate land areas 29, between the groups 28 of slots, provide a convenient space for the application of turbulence inducing ribs or wear bars 35 on the inner surface 30. The bars 35 may run the full height of the plate body 10 along the inner surface 30, on the land areas 29, and thus extend across the several annular rows of slots 25 in non-intersecting relation to the slots. The wear bars 35 are spaced angularly about the body from each other and run in generally parallel relationship, axially of the inner or inside surface 30. The technique of applying the wear bars by the application of weld material directly to the inner surface, permits the bars to be applied in other than straight lines and may be applied in curved regular or irregular patterns on such surface.

The wear bars 35 are preferably applied to the inner surface 30 at the lands 29 before the slots are cut through the body wall 20, and consist of weld beads which are applied directly to the surface, such as by a t.i.g. welder, and may consist of extremely hard cobalt-chromium-tungsten alloy. Such alloy is sold by Union Carbide & Chemical Corporation under the trade name "Stellite." The bars may be applied in a single pass or may be applied, one on top of the other, in two or more passes, to provide the desired elevation or thickness above the plate surface.

The forming methods provide an inside surface with a high degree of cylindrical accuracy, and permits the rotating foils to run closer to the inlet surface 30 than heretofore possible, and thus makes possible the use of turbulence inducing bars 35 which may consist of a single pass or single layer of weld bead material applied to the surface. The application of the beads, by welding, results in minimum penetration of the depth of the material of the wall 20 of the plate 10, and does not adversely

affect the resistance of the overall cylinder against fatigue failures due to the fact that the major portion of the underlying grain structure is not effected by the application of the wear bars 35.

The individual openings, such as the slots 25, are formed by laser energy beam cutting, through the outlet or outer surface 32 toward and into the inner or inlet surface 30. While a CO2 laser may be used, it is preferred to use a pulsed YAG laser, in which the beam is directed against the outer surface 32 and is focused at a region adjacent and immediately inwardly of the inner or inlet surface 30, with respect to the depth or thickness of the wall 20. Since the beam enters the wall from the outlet side and exits the wall at the inlet side, and since the beam itself is focused substantially at the inlet side, the opening formed by the beam at the region of breakthrough at the inner surface 30 is narrower than the opening formed at the outer surface 32. The extent of relief or taper is defined essentially by the convergence of the beam, with the result that the wall of the opening has a minimum of taper. The slots may be as small as 0.002" or as less as 0.035" or more.

The more critical dimension is that of the inlet opening or gap 38 of the individual slot 25, as shown in Fig. 4, which may, for example, be in the order of 0.010". Laser cutting of the slots provides a slot, in a 0.31" thickness plate, with an exit or outlet opening 39 of about 0.025", defined by generally straight walls 40. In this example, the total divergence of the walls is only in the order of 2.5°. Where desired, the inlet opening 38 may be smaller or larger than 0.010", and the exit opening 39 may be as wide as 0.040" or more. The slots 25 are transversely spaced at a density of 6 to the inch, although a greater or fewer number of slots, either narrower or wider in transverse dimension may be formed, as desired.

In the cutting of the slot 25, as the laser beam burns through the cylinder wall 20, the screen cylinder and beam are moved with respect to each other in an axial direction, with reference to the axis of the cylinder, to form a slot in which the narrow end 38 of the slot opens at the inlet surface, and the wider end 39 of the slot opens at the outlet surface, as shown in Fig. 5.

The walls 40 of the slots 25 are free of tool or machine marks. The slots 25 are characterized by walls 40 which have an extremely smooth and hard surface, thereby enhancing the efficiency of the screen. This is due to the fact that, during the cutting steps, the surfaces of the walls which define the slots are heated by the laser beam to a temperature as that a very thin exposed wall layer 42 (shown with exaggerated thickness in Fig. 5) is momentarily heated to a molten state. As the laser beam passes, the wall layer 42 rapidly cools due to the mass of material and the thinness of the layer which has been molten. The resulting coalescence forms a "glassy" or recast outer or exposed surface to the walls, which may undulate slightly, and which is very hard and free of tool marks. Thus, it has been found that these walls present a minimum of friction to the flow of stock therethrough with the result that the screen cylinder exhibits greater capacity as compared to cylinders in which the openings are conventionally cut or machined.

The laser cutting of the openings or slots through the wall 20 of the body 10 does not induce any latent or inherent stresses and, on the contrary, the heating and cooling cycle of the material which immediately surrounds the opening relieves stresses.

A screen cylinder may have one or more designs or patterns of slots or have slots which are inclined or sloping with respect to either an axial or a circumferential line. A screen cylinder 50 is illustrated in Fig. 6 in which the slots 52 are mutually inclined to each other and internested in a chevron-like pattern. Such a pattern can be formed by moving the screen plate in relation to the laser cutting tool as desired.

Fig. 7 shows a screen 54 in which the slots 55 are generally parallel to each other but are inclined to the axis of the screen plate, and the slots in each of the groups or rows may be, if desired, aligned with the slots in the adjacent group or row to provide a spiral-like appearance. Fig. 8 shows arcuately curved slots 60. Adjacent groups of slots 62 may be provided with a curvature in the opposite direction, if desired.

The holes or slots may be inclined as shown at 65 in the plate 68 of Fig. 9. The slurry 70 rotates within and along the inside surface 30 of the cylinder with a direction as represented by the arrow 71. The slots, or some of them, may be oppositely inclined. Openings or slots which are forwardly inclined increase the extraction efficiency by decreasing the head across the cylinder, and provide a screen cylinder with higher efficiency. Reverse inclined openings have the advantage of providing increased downstream cleanliness due to the superior ability of such openings to reject heavier and/or longer fibers and debris. Since the openings slant rearwardly or at an acute angle with respect to the direction of flow, any long or heavier fiber which enters the opening must first make a turn, with respect to the velocity vector, which turn may equal or exceed 90°, thereby making it more difficult for such a long or heavier reject to enter the opening.

Claims

1. The method of manufacturing a screen cyl-

inder for removing contaminant particles from papermaking stock in which a cylinder body is formed with an intermediate cylindrical section, and in which a plurality of closely spaced screening holes or slots are formed in the cylindrical section, characterized by the steps of:
forming the cylinder body as an integral seamless unit free of internal stresses and at the same time forming the intermediate section with generally uniform radial thickness throughout, thereby defining an inner surface and an outer surface, and
forming the holes or slots by directing a focused laser beam at the outer surface of the cylindrical section thereby forming a hole or slot with tapered walls.

2. The method according to claim 1 further characterized by the steps of forming the cylinder body with a pair of integral end rings and at least one intermediate reinforcing rib positioned on the outer surface axially intermediate the end rings, and in which the holes or slots are formed in the spaces between the rib and the end rings.

3. The method accordingly to any preceding claim further characterized by the step of moving the cylinder body with respect to the laser beam to form a slot.

4. The method according to any preceding claim in which the forming step is characterized by centrifugally casting the body.

5. The method according to claim 1 or 2 in which the forming step is characterized by cold roller extrusion.

6. The method according to any preceding claim characterized by the step of directing the laser beam against the outer surface of the body and focusing said beam adjacent said inner surface, to form a hole or slot with tapered walls which are wider at the outer surface than at said inner surface.

7. The method according to any preceding claim further characterized by the steps of applying wear bars by applying beads of weld material to the inner surface in non-intersecting relation to the holes or slots.

FIG-1

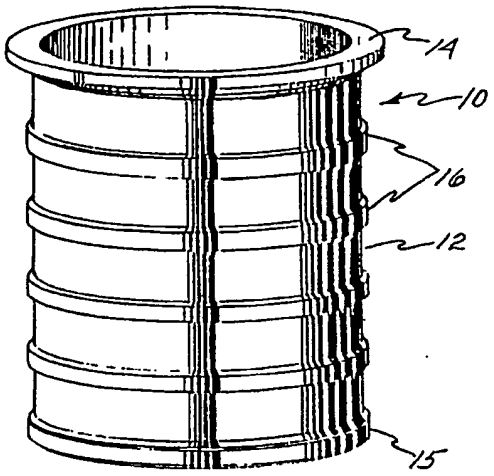


FIG-2

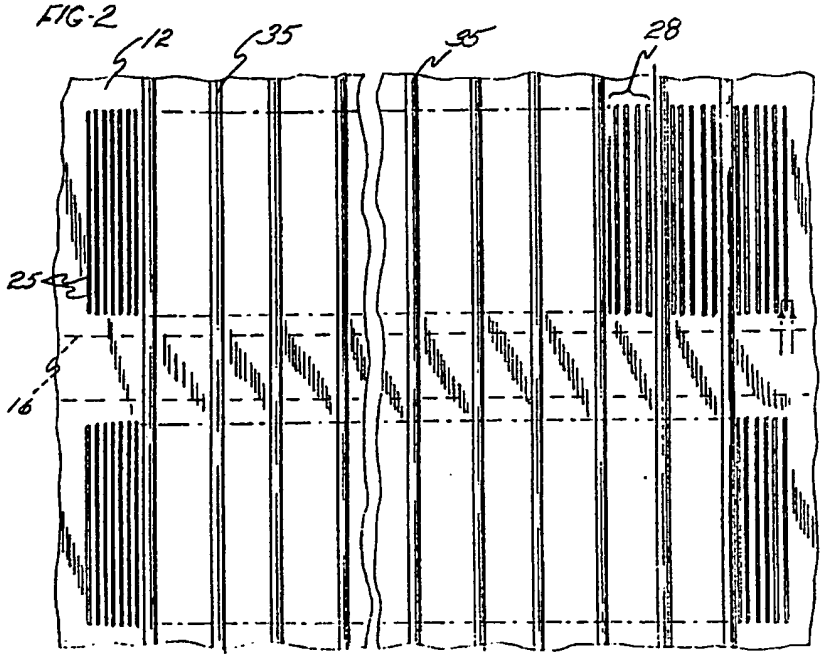


FIG-3

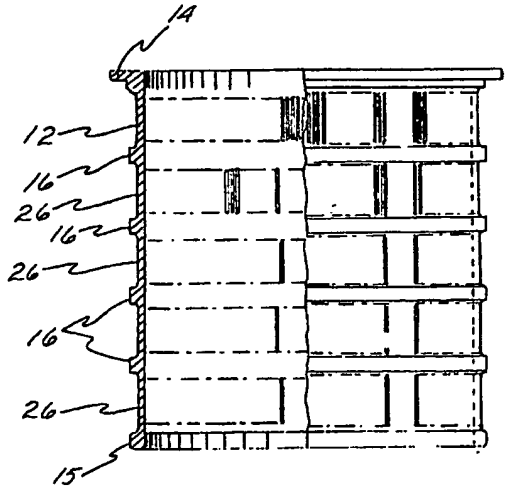


FIG-4

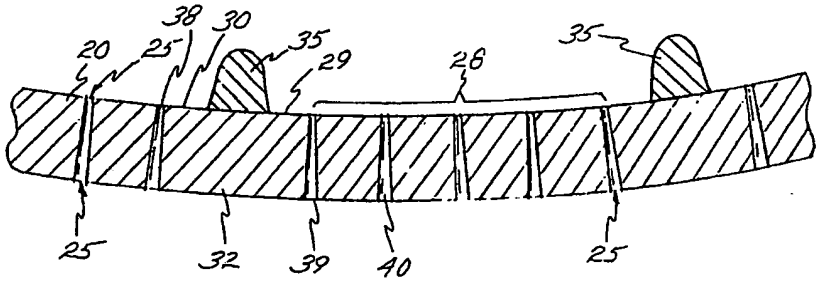


FIG-6

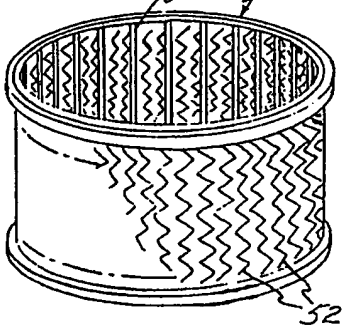


FIG-7

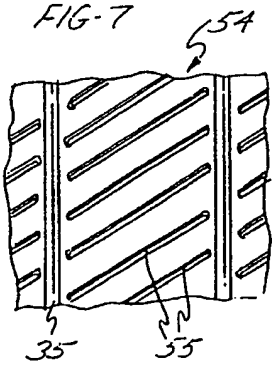


FIG-5

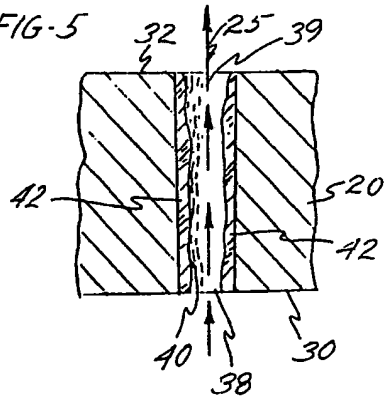


FIG-8

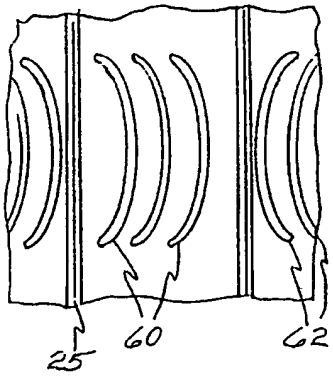
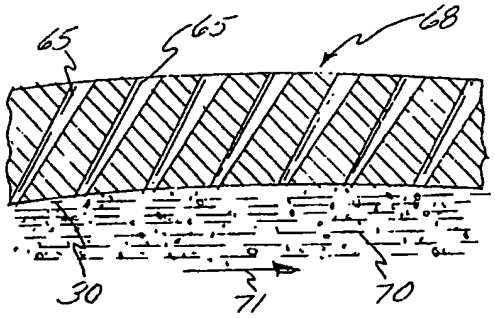


FIG-9



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EUROPEAN SEARCH REPORT

Application Number

EP 90313193.6

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US - A - 4 795 560 (CHUPKA) * Fig. 1-10 *	1-7	B 23 K 26/00 B 01 D 39/10
D,Y	US - A - 3 293 708 (FRUITMAN) * Fig. 1 *	1-7	
A	US - A - 4 343 358 (GRYSKIEWICZ) * Fig. 4 *	1	
A	US - A - 4 818 840 (BOOTH) * Fig. 1-6 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 23 K 26/00
B 01 D 39/00
B 22 D 13/00
B 23 P 15/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	11-02-1991	BENCZE

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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